BETHLEHEM STEEL CORPORATION,
SOUTH BETHLEHEM WORKS
(Bethlehem Iron Company, Bethlehem Works)
Along the Lehigh River north of Fourth Street
and west of the Minsi Trail Bridge
Bethlehem
Northampton County
Pennsylvania

HAER No. PA-386

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

BETHLEHEM STEEL CORPORATION, SOUTH BETHLEHEM WORKS
HAER NO. PA-386

Location: Along the Lehigh River north of Fourth Street and west of the Minsi Trail Bridge, City of Bethlehem, Northampton County, Pennsylvania.

UTM: 18.469580,4495980
Pennsylvania Quad: Bethlehem

Date of Construction: 1862 - present

Engineer/Builder: Alexander Holley, John Fritz, Henry Gray, and others

Present Owner: Bethlehem Steel Corporation, Bethlehem, Pennsylvania

Present Use: Integrated steel mill

Significance: Formed in 1857 as the Saconna Iron Company, this steel works along the Lehigh River was reorganized the following year as the Bethlehem Rolling Mill and Iron Company. Under the direction of Robert H. Sayre, the Bethlehem works grew over the next five years to include a blast furnace plant, puddling mills, and rolling mills. John Fritz supervised the design and construction of these structures. The company quickly emerged as one of the nation's leading iron rail producers. With the advent of the Bessemer process for steel making in the United States in the early 1870s, Bethlehem Iron invested in Bessemer steel plant designed by Alexander Holley. The steel plant of the Bethlehem Iron Company was the tenth American Bessemer works to begin production. By the 1880s, however, Bethlehem Iron began to diversify its products adding a heavy forging operation. The company also developed products ranging from structural steel sections (the wide-flange was first produced at Bethlehem) to tool steel. Throughout much of the twentieth century, the Bethlehem Steel Corporation, led by Charles Schwab and then Eugene Grace, was the nation's second leading steel maker. The South Bethlehem Works continues to serve as the corporation's central office.

Project Information:

This photographic documentation project of the early buildings at Bethlehem Steel Corporation's Bethlehem Works was conducted in July 1988 with Jet Lowe, HAER staff photographer, Gray Fitzsimons, HAER historian, and Lance E. Metz, the historian of the Hugh Moore Historical Park and Museums, Inc., Easton, Pennsylvania. The historical report was prepared by Lance Metz for the HAER documentation of Bethlehem Steel's Beth Forge Division (HAER No. PA-186). The section presented here is a summary of the general history of Bethlehem Steel from its founding to the 1880s, and was extracted from Metz's larger study of Beth Forge.

In 1857, a Bethlehem merchant, Augustus Wolle, became interested in the development of the Gangewere iron ore beds, which were located in the nearby Saucon Valley near the present borough of Hellertown. To exploit these deposits, Wolle organized the Sauconna Iron Company.[17] Among the initial subscribers was Asa Packer, who directed Robert H. Sayre to take an active role in its affairs. Realizing that the nascent enterprise, if properly directed, could provide an answer to the Lehigh Valley Railroad's rail source dilemma, Sayre used the financial resources of the Lehigh Valley Railroad to take effective management control of the Sauconna Iron Company. The company was reorganized in 1858 as the Bethlehem Rolling Mill and Iron Company, a name which better reflected its intended purpose. Influenced by Sayre, the company established its plant at the junction of the Lehigh Valley and North Pennsylvania railroads.[1] This location enabled the company to ship its products to markets in New York, Philadelphia, and the anthracite regions of Pennsylvania. Sayre also selected the skilled ironmaster who was needed to design the plant and supervise the company's operations. As a result of Sayre's actions, at the inaugural board meeting of the Bethlehem Rolling Mill and Iron Company, the directors hired John Fritz as their General Manager and Superintendent.[2]

John Fritz (1822-1913) was perhaps the most mechanically innovative of America's ironmasters. He had served since 1854 as the superintendent of the works of the Cambria Iron Company at Johnstown, Pennsylvania.[3] In 1857, Fritz had developed an innovative "three high" rail mill which made it possible, for the first time, to produce in America wrought iron railroad rails of uniformly high quality at an economical price. Unlike the commonly used "two high" rail mill, which was composed of only two sets of rolls, the three sets of rolls of the "three high" mill enabled a red-hot wrought iron pile to be completely rolled into a finished rail before it could cool and potentially shatter.[4] The "three high" rail mill was placed in successful operation on July 29, 1857 and John Fritz was granted a patent on his mechanical innovation on October 5, 1858.[5] This patent became the basis for a pool that would eventually involve almost all of the major American rail mills. Under the terms of his contract with the Bethlehem Rolling Mill and Iron Company, Fritz was appointed the general manager and superintendent of the company's works at a salary of $5,000 per annum, although the works were yet to be built. He also received a total of 100 shares of the company's stock to be paid in four annual installments in return for his granting free use of the "three high" rail mill patent.[6]

Despite the ravages of an 1862 Lehigh River flood, work on the manufacturing facilities of the Bethlehem Rolling Mill and Iron Company proceeded rapidly. The entire plant was designed by John Fritz, who also supervised its construction. By the time the No. 1 Blast Furnace was placed in operation on January 4, 1863, the

enterprise had been reorganized as the Bethlehem Iron Company.[7] By July 27, the puddling furnace had begun the production of wrought iron blooms for the rail rolling mill and by September 26, the Bethlehem Iron Company had begun the manufacture of high-quality wrought iron rails.[8]

The financial support of the highly profitable Lehigh Valley Railroad enabled the Bethlehem Iron Company to expand its operations during the 1860s.[9] By the end of 1863, the works of the Bethlehem Iron Company had grown to include four stationary steam engines, a blast furnace, fourteen puddling furnaces, nine heating furnaces, a 21" (based on the diameter of the rolls) puddle train, and a 21" rail train. The Bethlehem Iron Company's No. 2 Blast Furnace was constructed in 1867 and a year later a large foundry and machine shop complex was completed.[10] To further increase its pig iron production capacity, the company purchased from the Northampton Iron Company an unused blast furnace located on an adjacent property. The acquisition of No. 3 Blast Furnace raised the company's ironmaking capacity to an annual total of 30,000 tons.[11]

The Bethlehem Iron Company soon won a major share of the eastern railroad rail market due to the superior quality of its product. However, a new product, Bessemer steel rails, began to appear in America during the 1860s, and the superior durability of this British import attracted the attention of major American lines. Although Bessemer steel rails were far costlier than wrought iron rails, they lasted three times longer. As early as 1864 the Lehigh Valley Railroad, under Robert H. Sayre's direction, began to import Bessemer steel rails.[12] This importation was done in response to the activities of the Lehigh Coal and Navigation Company, which was extending its competing Lehigh and Susquehanna Railroad to parallel almost the entire route of the Lehigh Valley Railroad.[13]

The Lehigh Coal and Navigation Company was using imported Bessemer steel rails and Sayre feared that this innovation would greatly reduce the Lehigh and Susquehanna Railroad's maintenance costs and give it an economic advantage over the Lehigh Valley Railroad. In response, he began to prod the Bethlehem Iron Company to investigate the production of Bessemer steel rails.[14] However, John Fritz was opposed to this proposed technical innovation. Fritz had earlier visited an experimental Bessemer steel works at Troy, New York. This plant, which was run by the firm of Winslow and Griswold under the technical direction of Alexander Holley, had installed a small converter and their early results had been poor due to the presence of phosphorus in most American iron ores. Since a phosphorus level greater than 0.02 made steel produced in a Bessemer converter extremely brittle, Fritz felt that the Bessemer process was useless to most American iron makers.[15] Fritz had also witnessed William Kelly's singularly unsuccessful steelmaking experiments in western Pennsylvania during his tenure

at Cambria. Kelly's experiments, which were similar in concept to the Bessemer process, had not resulted in a usable product and the failure of Kelly's work had given Fritz additional cause for his reluctance to commit Bethlehem to the construction of a steelmaking plant. Fritz changed his mind upon learning about the key discovery that made it possible to utilize iron that was relatively high in phosphorus in a Bessemer converter.[16]

In its original form, the Bessemer process centered on the introduction of a blast of air into a refractory-lined iron vessel, or converter, that held a quantity of molten pig iron.[17] The oxygen in the air blast ignited and burned away much of the carbon in the pig iron, a process which produced steel. The process was initially developed by British inventor Henry Bessemer (1813-1898), and it was first publicly announced in 1856. However, molten pig iron made from ores that were relatively high in phosphorus produced a brittle metal when subjected to Bessemer's process. This technical problem was solved by the work of pioneer British metallurgist, Robert F. Mushet (1811-1891). Mushet found through extensive experimentation that the introduction of a ferromanganese alloy known as Spiegeleisen into a converter produced a metallurgical reaction when blown that reduced the detrimental effects of phosphorus and sulfur and also increased the carbon content of the converter's charge.[18] The resulting steel possessed a hardness and strength that made it suitable for many uses including the rolling of railroad rails. Due to the joint efforts of Alexander Holley, an engineer who had brought knowledge of the Bessemer process to America, Daniel K. Morrell, the general manager of Wood Morrell and Company, the operators of Johnstown's Cambria Iron Company, and Holley's employers, ironmasters John Griswold and John F. Winslow of Troy, New York, an amalgamation of the American rights to the patents of Kelly, Bessemer and Mushet, known as the Pneumatic Steel Association, was created in 1865. In response to the prodding of Robert H. Sayre, the Bethlehem Iron Company became a member of this cartel in 1867.

The entry of Bethlehem into the Pneumatic Steel Association propelled John Fritz to the forefront of the efforts to create a viable Bessemer steel industry in the United States. He quickly absorbed the best available knowledge on the subject through consultations with technical experts.[19] To this knowledge he applied his mechanical engineering genius and together with his brother, George Fritz, the general superintendent at Cambria, and Alexander Holley, he played a large role in the design of the works of the Pennsylvania Steel Company at what is now Steelton, Pennsylvania. This plant was placed into operation in 1867; it was the first commercially successful Bessemer steel plant in America.[20] In 1868, John Fritz went to Europe to examine steel works in England, France, Germany, and Austria.[21] When he returned from this trip, Fritz began work on the Bethlehem Iron Company's Bessemer steel plant. He was aided in this project by Alexander Holley, who

made several extended visits to Bethlehem.[22] Due to Fritz's desire to make Bethlehem's plant the most mechanically efficient of America's Bessemer steel works, it was not placed in full operation until October 4, 1873.[23]

In many ways, the Bessemer steel plant that John Fritz designed for the Bethlehem Iron Company can be considered the first serious attempt to achieve integration in the production of both steel and rails. This achievement was early recognized by Fritz's contemporaries. Robert W. Hunt, a pioneering metallurgist, chemist, and mechanical engineer who was involved in some of the earliest attempts to create a Bessemer steel plant in America, described Fritz's plant in the following passage from his work "A History of Bessemer Manufacture in America," which appeared in Vol. 5 (1876-1877) of The Journal of the American Institute of Mining Engineers.

> He arranged his melting-house, engine room, converting-room, blooming and rail mills, all in one grand building, under one roof, and without any partition walls. He placed his cupolas on the ground and hoisted the melted iron on a hydraulic lift and then poured it into the converters. The spiegel is also hoisted and poured into the vessels.... Instead of depending upon friction to drive the rollers of the tables, Mr. Fritz put in a pair of small reversing engines.[24]

A more complete description of the blast furnaces, rolling mills, and Bessemer steel plant of the Bethlehem Iron Company is provided in the following passage from the 1873 Guide Book of the Lehigh Valley Railroad:

> The largest manufacturing establishment here is that of the Bethlehem Iron Company, including within its operations, which began in January, 1863, furnaces, rolling mills, machine shop and foundry. Its capital stock is $1,000,000. The measurement of the three stacks is as follows: No. 1, 15 by 63 feet; No. 2, 15 by 45 feet; No. 3, 14 by 50 feet. Their combined capacity is about 30,000 tons per annum. The largest part is used in the adjoining rolling mill, whose capacity is 20,000 tons per annum. Its consumption of raw materials is 70,000 tons of Pennsylvania hematite and New Jersey magnetic ore and from 70,000 to 75,000 tons of coal. The total number of men employed at the works proper is about 700. The new building now erecting for the manufacture of iron and steel will be, it is said, the largest in this country and one of the largest in existence anywhere. It will be 105 feet wide spanned by an iron and slate roof without supporting columns. It is 30 feet high to the eaves and

is in the shape of a double cross of which the long arm [or main building] is 941 feet and the short arms 140½ each, making the area covered 1493 by 105 feet. This is only surpassed by the mill at Creuzot in France, which consists of three buildings 60 by 1400 feet each.

The steel works will start with a capacity of about 600 tons of rails per week, planned and arranged for a threefold increase of the same. There will be three trains of rolls, say 24, 26 and 30 inch diameters, driven by two condensing-engines of 48 and 56 inches diameter cylinders, of 46 and 48 inches stroke.

The mill will be remarkable not only for its enormous size and capacity, but for the many new labor saving conveniences introduced.

The iron work for the building as well as the machinery was all made at the Company's shops and foundry.[25]

Another contemporary description of the Bethlehem Iron Company's productive facilities during the 1870s is contained in the following passage from Frank H. Taylor's 1878 book, Autumn Leaves Upon the Lehigh:

The extensive works of the Bethlehem Iron Company occupy a large area along the river [Lehigh]. They comprise a Bessemer plant, two large rolling-mills and six blast furnaces, beside supplementary foundry and machine-shops for construction and repairs. A number of valuable iron mines are also owned by the Company. The several railroad lines centering here tend to make this an especially advantageous point for the prosecution of iron manufacture. The reputation for superior quality of steel established by this company is largely owing to the fact that they manufacture their own pig metal and secure for this purpose the best Bessemer ores in the world; drawing their supply largely from Africa, Spain, and our Lake Superior district. The best hematite ores are within easy reach as well as the magnetic ores of the great Cornwall deposit near Lebanon. Ores are also obtained from Lake Champlain being shipped by water to Amboy and thence by rail. A considerable amount also of magnetic ore from New Jersey finds it way to Bethlehem.

The coal used in smelting is anthracite from the Lehigh region and bituminous from the Schroeder mines in Bradford County.

These works were started in 1860 with the erection of an iron rail, a puddle mill and one blast furnace--additional structures having been added at various times as the increasing trade of the concern

demanded.

All the buildings are fine, massive, stone structures, the length of the steel mill being 931 feet. The capacity per annum is 60,000 tons steel rails, billets, etc., and 20,000 tons manufactured iron. A full equipment of the most approved appliances for iron and steel may be found here.

At the present time, the Company is engaged in the manufacture of steel rails, rails billets, shovel slabs, etc. and iron rails, cotton ties and band iron.[26]

The steel plant of the Bethlehem Iron Company was the tenth American Bessemer works to begin production.[27] By 1878-1879 it produced over 78,697 tons of steel, a figure that was exceeded only by the 84,356 tons that were produced by the Cambria Iron Company and the 95,475 tons that were produced by the Carnegie group's new Edgar Thomson Steel Company of Braddock, near Pittsburgh.[28] Bethlehem was thus one of the leading steelmakers in a competitive market with no single plant dominating the field. However, the production leadership that the Edgar Thomson works had achieved in 1875-1879 was a harbinger of its latter dominance.

By the early 1880s, the steel works of the Carnegie group and other manufacturers in the Pittsburgh region had assumed a commanding position in the American rail market, gained largely at the expense of eastern railmakers. Kenneth Warren, in his study of America's steel industry, notes several factors that brought about this change. He cites, for example, the sharp lowering of the mining and transportation costs of Lake Superior ores coupled with increased mechanization of unloading facilities at the Great Lakes ports and improved rail transportation from the ports to Pittsburgh. Equally as important, Warren states that many of the eastern railmakers, such as Bethlehem, lacked adequate captive domestic supplies of low-phosphorus iron ores and were forced to depend on foreign mines.[29] Many of the eastern railmakers were further handicapped by the expenses of the tariffs on these imported iron ores and the additional costs of shipping them inland to their plants by railroads. According to Warren, the costs of transporting ore by ship and rail from the Great Lakes to Pittsburgh rose far more slowly than the costs of importing foreign ores and shipping them inland, placing the eastern rail mills at a further disadvantage. Warren also notes that as the eastern railmakers increasingly switched from anthracite to coke for blast furnace fuel, they faced additional costs. Companies such as the Pennsylvania Steel Company, the Lackawanna Iron and Coal Company, and the Bethlehem Iron Company had originally enjoyed favorable locations in relation to the anthracite coal fields. The cost of transporting anthracite to these plants was relatively low, but when coke, because of its higher caloric value, began to replace anthracite as a blast furnace fuel, the eastern railmakers were

faced with the much greater costs of the rail transportation of bituminous coking coal from southwestern Pennsylvania. They were further handicapped by the fact that through his control of the Henry Clay Frick Coke Company, Carnegie could supply his steel mills with low-cost coke of superior quality, while the eastern steel companies were forced to pay higher open market prices for their coking coal.[30]

The cumulative effects resulted in an increasing production of rails concentrated at a few large mills. In 1884 there were seventy-one rail mills operating in various parts of the United States. By 1887 many of these mills were closed. During that year an attempt was made to limit competition by forming a rail manufacturing pool composed of the fifteen remaining major producers. However, the pool was not a success and by 1892 Carnegie's plants manufactured almost 25% of the annual total production of rails in America. Carnegie's success presented a major dilemma for Bethlehem and the other remaining rail mills due to the fact that as Carnegie increased sales their market share declined. The Bethlehem Iron Company was faced with an ever-shrinking market for its steel rails during the 1880s. As a result, it switched its emphasis to the production of high-grade rails that were rolled from low phosphorus steel billets. It was able to charge a higher price for these rails until competing mills began to make similar products.[31] By 1902, the Bethlehem Iron Company had totally ceased the production of steel rails. However, it continued to prosper and escaped the desolate fate of other eastern rail manufacturers, such as the Troy Steel Company which was closed down and scrapped in 1902, because it developed a new product line centered around the introduction of heavy-forging technology into America.[32]

Endnotes

1. Lance E. Metz, John Fritz: His Role in the Development of the American Iron and Steel Industry and His Legacy to the Bethlehem Community, Easton, Pa.: Center for Canal History and Technology, 1987, 16. See also W. Ross Yates (ed.), Bethlehem of Pennsylvania: The Golden Years, Bethlehem, Pa.: Bethlehem Book Committee, 1976, 30. See also An Historical Sketch of the Development of the Bethlehem Steel Company and the Bethlehem Steel Corporation, Bethlehem, Pa., 1912, 3.
2. Minutes of the Meeting of the Board of the Bethlehem Rolling Mills and Iron Company, June 14, 1860. (Xerox copies of original minute book on deposit at the Hagley Museum and Library, Wilmington, Delaware, and the Hugh Moore Historical Park and Museums, Inc., Easton, Pennsylvania)
3. John Fritz, The Autobiography of John Fritz, New York, N.Y.: John Wiley and Sons, 1912, 91-134 (actually the works of the Cambria Iron Company were under the control of the firm of Wood Morrell and Company).
4. Lance E. Metz and Donald Sayenga, "John Fritz and the Development of the Three-High Rail Mill 1855-1863," Papers of the 1989 SIA Conference, Quebec City, Canada, 11-14.
5. Ibid.; 18.
6. Agreement between John Fritz and the Bethlehem Rolling Mill and Iron Company July 10, 1860, contained in the Fritz Collection of the Hugh Moore Historical Park and Museums, Inc., Easton, Pa.
7. Craig L. Bartholomew and Lance E. Metz (Ann Bartholomew Ed.), The Anthracite Iron Industry of the Lehigh Valley, Easton, Pa.: Center for Canal History and Technology, 179. See also W. Bruce Drinkhouse, Bethlehem Steel Corporation: A History from Origin to World War I, Easton, Pa.: Northampton County Historical and Genealogical Society, 1969, 4-5, and Historical Sketch of the Development of Bethlehem Steel Company and Bethlehem Steel Corporation, Bethlehem, Pa.: Bethlehem Steel Corporation, 1912, 3.
8. R.D. Billinger, "Beginnings of Bethlehem Iron and Steel," Bulletin of the Commonwealth of Pennsylvania Department of Internal Affairs, Vol. 20, Feb. 1953, 5. See also Bartholomew and Metz, The Anthracite Iron Industry of the Lehigh Valley, op. cit., 179 and the undated memo of important dates in the history of the Bethlehem Iron Company compiled by the company's secretary, Abraham Schropp, contained in the Fritz Collection. Hugh Moore Historical Park and Museums, Inc., Easton, Pa.
9. W. Ross Yates, Joseph Wharton, Quaker Industrial Pioneer, Bethlehem, Pa.: Lehigh University Press, 1987, 140-144.
10. Bartholomew and Metz, Anthracite Iron Industry of the Lehigh Valley, op. cit., 180.
11. Bartholomew and Metz, Anthracite Iron Industry of the Lehigh

Valley, op. cit., 179-180. See also W. Bruce Drinkhouse, The Bethlehem Steel Corporation: A History from Origin to World War I, Easton, Pa.: The Northampton County Historical and Genealogical Society, 1964, 5; and minutes of the meetings of the board of the Bethlehem Iron Company, April 8 and September 23, 1868. (Xerox copies of original minute book on deposit at Hagley Museum and Library, Wilmington, Delaware and the Hugh Moore Historical Park and Museums, Inc., Easton, Pa.)

12. Yates, Bethlehem of Pennsylvania, op. cit. 115.
13. Yates, Joseph Wharton, op. cit., 146.
14. Donald Sayenga, "Canals, Converters and Cheap Steel," Canal History and Technology Proceedings, Vol. VIII, 1989, 94-95.
15. John Fritz, Autobiography, op. cit., 150. See also Jeanne McHugh, Alexander Holley and the Makers of Steel, Baltimore, Maryland: John Hopkins University Press, 1980, John Bergenthal, "The Troy Steel Company and its Predecessors" (an unpublished 1987 manuscript that is an enlargement of a senior thesis at Rensselaer Polytechnic Institute, Troy, N.Y.) and Phillip Bishop.
16. Lance E. Metz, John Fritz: His Role in the Development of the American Iron and Steel Industry and His Legacy to the Bethlehem Community, Easton, Pa.: Center for Canal History and Technology, 1987, 19.
17. McHugh, Alexander Holley, op. cit., 93-103.
18. U.S. Patent No. 17,389 granted to Robert F. Mushet, May 26, 1867. See also E.F. Longe, Bessemer, Goronsson and Mushet, Manchester, England, 1913.
19. The entries in Robert H. Sayre's diaries for October of 1865 contain many references to meetings between Sayre, Fritz and professors of chemistry, metallurgists and other experts who were working to perfect the Bessemer process.
20. McHugh, Alexander Holley, op. cit., 301. See also Quincy Bent, "History of the Steelton Plant" (unpublished undated manuscript contained in the Bethlehem Steel Collection, Hugh Moore Historical Park and Museums, Inc., Easton, Pa. Quincy Bent was the son of Luther Bent, former general manager of the plant and the grandson of Samuel Felton, the first president of the Pennsylvania Steel Company. See also Mark Reuter, Sparrows Point: Making Steel -- the Rise and Ruin of American Industrial Might, New York, N.Y.: Summit Books, 1988, 17-34.
21. Diary of 1868 European trip in the Fritz Collection at the Hugh Moore Historical Park and Museums, Inc., Easton, Pa. This journey was compiled by George Fritz, who accompanied his brother, E.P. Wilbur of the Lehigh Valley Railroad, Harry Packer, the son of Asa, and Abram S. Hewitt of the Trenton Iron Company on this fact-finding tour.
22. McHugh, Alexander Holley, op. cit., 241-244. See also John Fritz, Autobiography, 152-158.
23. "Unpublished list of historical dates of the Bethlehem Iron Company" compiled by Abraham S. Schrapp, contained in the John

Fritz Collection, Hugh Moore Historical Park and Museums, Inc., Easton, Pa.

24. Robert W. Hunt, "A History of Bessemer Manufacture in America," The Transactions of the American Institute of Mining Engineers, Vol. 5 (1876-1877), 212-213.
25. Guide-Book of the Lehigh Valley Railroad and Its Several Branches and Connections with an Account Descriptive and Historical of the Places Along their route; Including Also History of the Company from its First Organization and Interesting Facts Concerning the Origin and Growth of the Coal and Iron Trade in the Lehigh and Wyoming Regions, Philadelphia, Pa.: J. B. Lippincott & Co., 1873, 42-43.
26. Frank H. Taylor, Autumn Leaves Upon the Lehigh: Picturesque and Industrial Scenes Along the Line of the Lehigh Valley Railroad, Philadelphia, Pa.: James W. Nagle, 8-9.
27. McHugh, Alexander Holley, op. cit., 242.
28. Handwritten note chart listing the production tonnage of eleven American steel plants, one of a series of similar items in the Robert H. Sayre Collection, Hugh Moore Historical Park and Museums, Inc., Easton, Pa. It should be noted that the Edgar Thomson works had only begun production in 1875.
29. Kenneth Warren, The American Steel Industry: A Geographical Interpretation, Oxford, Great Britain: Clarendon Press, 1973, 96-103. After 1883 the Bethlehem Iron Company was forced to increasingly depend on the Juraga mines in Cuba. It operated these mines as a partnership with the Pennsylvania Steel Company.
30. Ibid.
31. Ibid.
32. The demise of Troy Steel is examined in John Bergenthal's "The Troy Steel Company and its Predecessors" (an unpublished 1987 manuscript that is an enlargement of a senior thesis at Rensselaer Polytechnic Institute, Troy, NY).

ADDENDUM TO
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